APPENDIX N

ECOLOGICAL RISK ASSESSMENT

The Oeser Company Superfund Site
Final Ecological Risk Assessment
Bellingham, Washington
TDD: 01-03-0016

Contract: 68-S0-01-01
April 2002

Region 10

START-2

Superfund Technical Assessment and Response Team

Submitted To: Loren McPhillips, Remedial Project Manager
United States Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, Washington 98101

THE OESER COMPANY SUPERFUND SITE
FINAL ECOLOGICAL RISK ASSESSMENT
BELLINGHAM, WASHINGTON

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

Acronym	Definition
BAF	bioaccumulation factor
BW	body weight
COCs	contaminants of concern
COPCs	contaminants of potential concern
CSM	conceptual site model
ED	exposure duration
EPA	United States Environmental Protection Agency
EPCs	exposure point concentrations
ERA	ecological risk assessment
FS	feasibility study
HQ	hazard quotient
IR	ingestion rate
kg	kilogram
LOAEL	lowest observed adverse effect level
mg/kg	milligrams per kilogram
NOAEL	no observed adverse effect level
PAHs	polycyclic aromatic hydrocarbons
PCP	pentachlorophenol
ppm	parts per million
RI	remedial investigation
SUF	site use factor
TCDD	tetrachlorodibenzo-p-dioxin
TEQ	toxicity equivalent
TRV	toxicity reference value
UCL	upper confidence limit

THE OESER COMPANY SUPERFUND SITE
FINAL ECOLOGICAL RISK ASSESSMENT
BELLINGHAM, WASHINGTON

1. INTRODUCTION

The work plan for The Oeser Company site (E & E 1999; Figure 1-1) presented a screening-level problem formulation and an ecological effects evaluation based on a review of existing site information. This analysis identified natural areas that may be impacted adversely by facility operations, identified contaminants of potential concern (COPCs), and presented a preliminary conceptual site model (CSM). The screening-level analysis concluded that additional ecological risk assessment (ERA) work was warranted for two primary reasons: (1) concentrations of several chemicals in sediment samples collected from Little Squalicum Creek exceeded benchmarks for the protection of benthic life and (2) insufficient data were available to evaluate risks to wildlife from site-related chemicals. Specifically, no dioxin data were available for Little Squalicum Creek, and no data for dioxin, metals, polycyclic aromatic hydrocarbons (PAHs), and chlorinated phenols were available for the south slope terrestrial area. These data gaps and others were addressed by sampling conducted under the remedial investigation (RI)/feasibility study (FS) work plan in 1999.

This document presents an ERA conducted with the 1999 RI/FS sampling data. Detailed descriptions of The Oeser Company and the sampling conducted on and off the facility property are contained in *The Oeser Company Superfund Site Remedial Investigation Report* (E & E 2002). The assessment was conducted in accordance with accepted federal guidance, including:

- *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA 1997);
- *Guidelines for Ecological Risk Assessment* (EPA 1998b); and
- *Wildlife Exposure Factors Handbook* (EPA 1993a, b).

In addition, publications from Oak Ridge National Laboratory (Efroymson, Will, and Suter 1997; Efroymson *et al.*1997; Sample, Opresko, and Suter 1996; Sample *et al.* 1997) and recent articles from peer-reviewed literature were used, where appropriate. The general objective of the ERA was to evaluate environmental samples for site-related contaminants and to estimate potential risks these contaminants pose to the natural environment. The assessment was focused on Little Squalicum Creek and the south slope terrestrial area.

This ERA is organized into seven major sections. Section 2 presents a problem formulation, which summarizes the site ecology, COPCs, ecological receptors, and possible exposure pathways. Assessment endpoints and measures of effect are described in Section 3. Section 4 presents an aquatic life risk evaluation, Section 5 presents an evaluation of risks to plants and soil fauna, and Section 6 presents an evaluation of risk to wildlife. A discussion of uncertainties in the ERA is presented in Section 7, and a summary of the ecological risks is presented in Section 8. References are in Section 9 of this report.

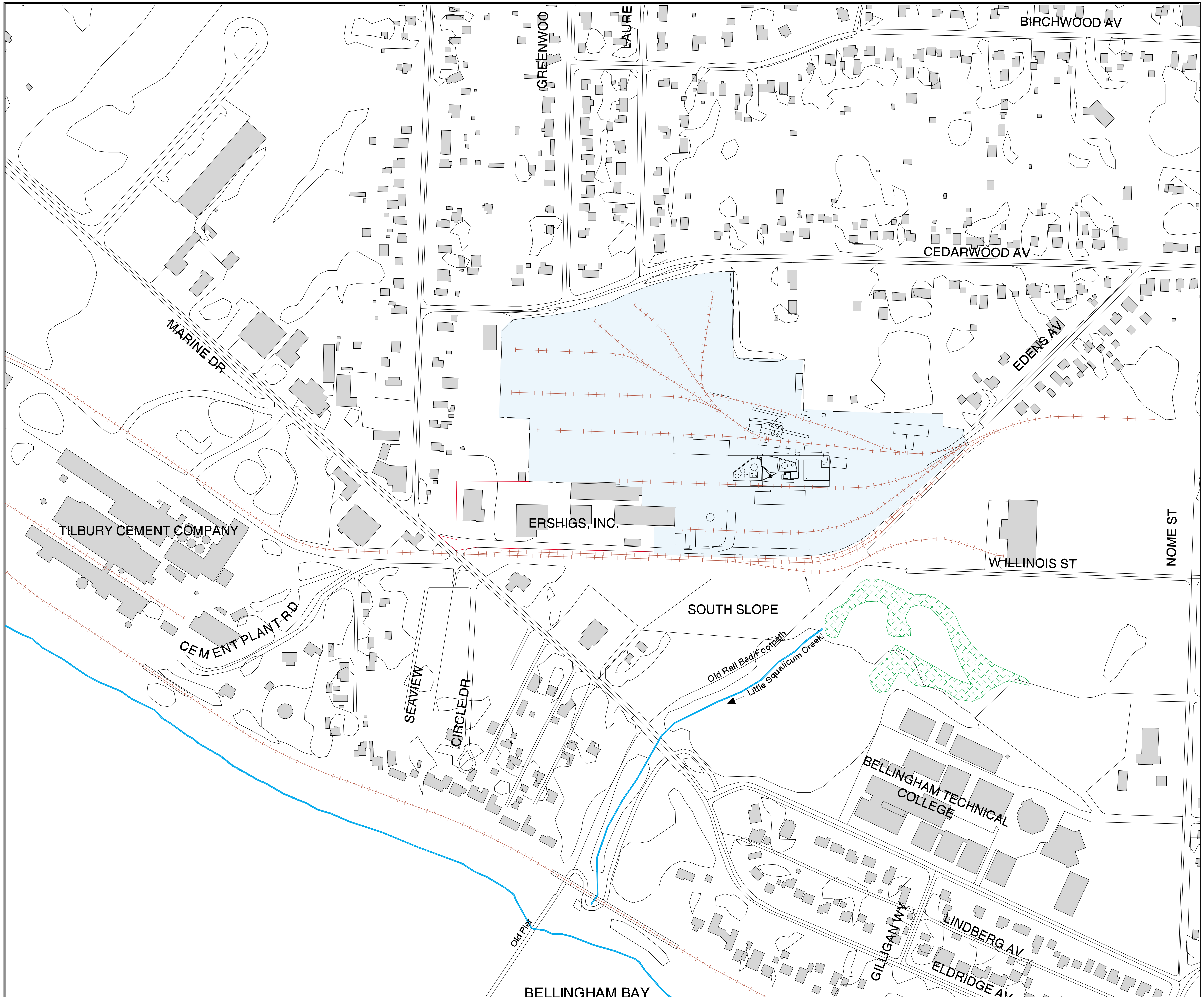


Figure 1-1

THE OESER COMPANY SUPERFUND SITE

Bellingham, Washington

Ecological Risk Assessment

Site Map

Legend

- The Oeser Company Facility
- Wetlands
- Building/Residential Structure
- Shoreline and Waterways
- Railroad Line
- Flow Direction

N
W E
S

0 250 500 750 1000

Feet

MAP SOURCE

City of Bellingham - Department of Public Works
Topographic Data Date: 1988

Oeser Company Site Map
Larry Steele & Associates
Survey Date: 12/3/1997

ecology and environment, inc.
International Specialists in the Environment
Seattle, Washington

/data1/oeser/rifs/fig1-1-era.aml

2. PROBLEM FORMULATION

2.1 SITE ECOLOGY

Little Squalicum Creek and the south slope terrestrial area (Figure 2-1) are valuable natural areas that are attractive to wildlife. The creek area and south slope area are adjacent, allowing wildlife to move freely between the two areas. Both areas are relatively undisturbed and are vegetated with trees, shrubs, and various grasses. Several species of songbirds and mammals use these areas, including the American robin, the red-winged blackbird, swallows, rabbits, and squirrels. In addition, the creek provides a source of drinking water for wildlife and supports benthic life, including various species of aquatic insects, which can be a source of food for some wildlife species. A more detailed description of the creek and south slope area is provided in Section 3.3 of the RI report (E & E 2002).

The Oeser Company facility itself will not be evaluated in the ERA. Because of its highly disturbed condition, the facility is of little ecological value. Most of the facility is paved with asphalt, covered with gravel, or vegetated by regularly maintained grass. In addition, there is considerable human activity on the facility that would deter wildlife from using it. Although some wildlife species occasionally may visit the facility, they are not expected to reside there or to derive a large part of their food or habitat requirements from the facility property.

2.2 CONTAMINANTS OF POTENTIAL CONCERN

As presented in the work plan (E & E 1999), numerous investigations conducted at The Oeser Company site during the past two decades have documented the presence of facility-related chemicals, such as pentachlorophenol (PCP) and PAHs, in soil and shallow groundwater on The Oeser Company facility and in nearby off-facility areas, such as Little Squalicum Creek. A review of these investigations also identified data gaps relevant to the assessment of ecological risks at the site. Most notably, no dioxin/furan data were available for the site, and no historic sampling data for any chemicals were available for the south slope area. These data gaps and others were addressed by sampling conducted for the RI/FS in 1999.

The 1999 data indicate that environmental media in nearby off-facility areas are contaminated with PAHs, PCP, and/or dioxins/furans (see Section 4 of the RI report [E & E 2002]). Specifically, in some reaches of Little Squalicum Creek, concentrations of PAHs, PCP, and dioxins/furans in sediment are elevated above background and conservative benchmarks for the protection of benthic life. In addition, surface soil contamination by site-related chemicals also was evident in the 1999 data. Specifically, PAH concentrations in surface soil from along the banks of the creek, and PCP and dioxin/furan concentrations in surface soil from the south slope area were elevated above background concentrations. As a result, PAHs, dioxin/furans, and PCP were selected as contaminants of concern (COCs) for the ERA.

2.3 ECOLOGICAL RECEPTORS AND EXPOSURE PATHWAYS

Once in Little Squalicum Creek, facility-related chemicals have the potential to adversely affect aquatic life, as well as birds and mammals that use the creek as a source of food or water or both. The flora and fauna of the south slope and creek area are described briefly above (Section 2.1) and in greater detail in Section 3.3 of the RI report (E & E 2002). Potential exposure pathways and receptors at the site are summarized in the CSM shown in Figure 2-2. Benthic invertebrates and amphibians in the creek could be exposed to facility-related chemicals through direct contact with contaminated water and sediment, incidental ingestion of sediment, and the food chain. Wildlife using the creek could be exposed to COPCs through incidental sediment ingestion, drinking of creek water, and the food chain. Because Little Squalicum Creek does not support fish, a fish-consumption pathway is not applicable to the site. The most likely food chain exposure pathway for the creek ecosystem would involve consumption of aquatic invertebrates from the creek by local wildlife. For example, insectivorous songbirds may consume aquatic insects from the creek after they emerge. PAHs, PCP, and dioxins/furans all have the potential to accumulate in aquatic invertebrates as a result of their lipophilic nature and, thus, may pose a food chain threat. Although drinking of creek water is shown in Figure 2-2 as a possible route of exposure for wildlife, this exposure route likely is of minor importance since lipophilic organic chemicals were found at lower concentrations in surface water compared to concentrations found in sediment. This is a consequence of the tendency of lipophilic organic chemicals to bind to organic matter and other sediment solids. Because of the protection provided by fur and feathers, direct contact with contaminated sediment and surface water also is considered a minor route of exposure for wildlife.

Potential receptors and exposure pathways for the south slope area and for the riparian zone that borders the creek also are included in Figure 2-2. Vegetation in these areas may be affected by contact with contaminated soil and possibly by deposition of airborne contaminants onto plant surfaces. Soil invertebrates, such as earthworms, may be affected by direct contact with contaminated soil and through soil ingestion. Birds and mammals may be affected by incidental ingestion of contaminated soil and through consumption of contaminated food items, such as soil invertebrates. Because of the protection provided by fur and feathers, direct contact with contaminated soil is considered a minor route of exposure for wildlife.

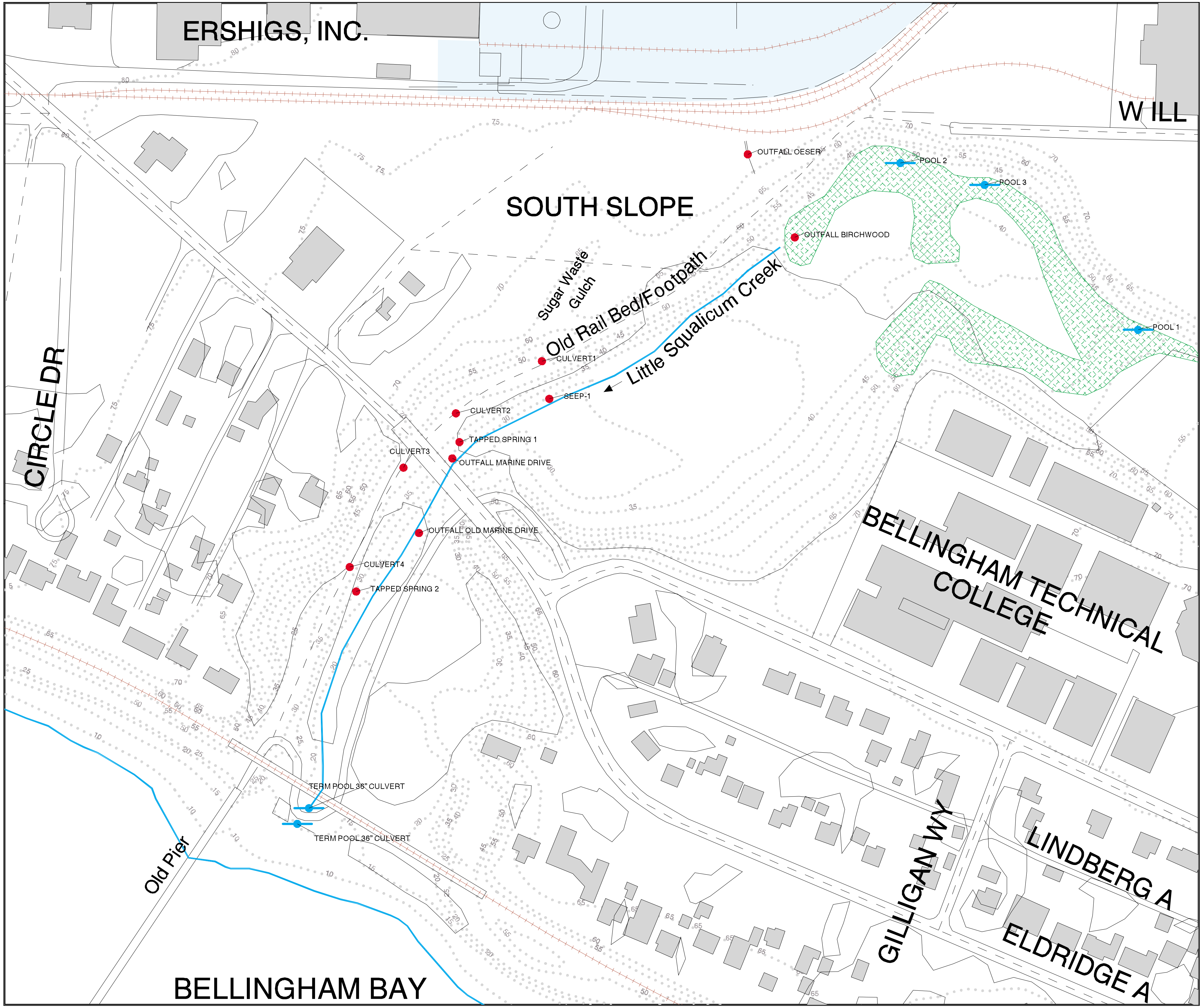


Figure 2-1

THE OESER COMPANY SUPERFUND SITE

Bellingham, Washington

Ecological Risk Assessment

South Slope and Little Squalicum Creek

Legend

- The Oeser Company Facility
- Wetlands
- Building/Residential Structure
- Shoreline and Waterways
- Railroad Line
- Contour Interval
- Flow Direction

N W E S

0 100 200 300 400 500

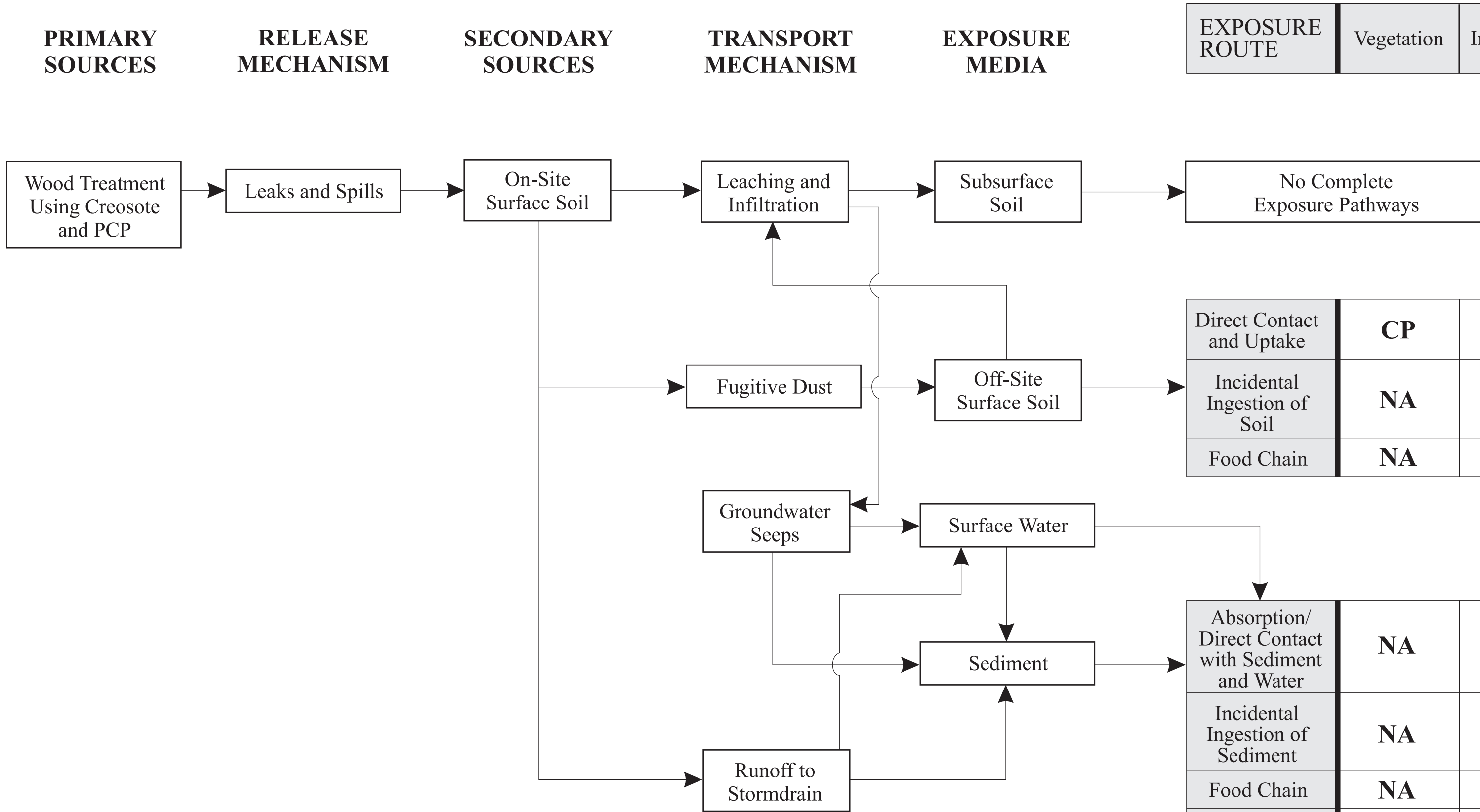
Feet

MAP SOURCE

City of Bellingham - Department of Public Works
Topographic Data Date: 1988

ecology and environment, inc.
International Specialists in the Environment
Seattle, Washington

/data1/oeser/rifs/fig2-1-era.aml



ECOLOGICAL RECEPTORS

EXPOSURE ROUTE	Vegetation	Invertebrates	Amphibians	Wildlife
Direct Contact and Uptake	**CP**	**CP**	**NA**	**CP-M**
Incidental Ingestion of Soil	**NA**	**CP**	**NA**	**CP**
Food Chain	**NA**	**CP**	**NA**	**(CP)**

EXPOSURE ROUTE	Vegetation	Invertebrates	Amphibians	Wildlife
Absorption/ Direct Contact with Sediment and Water	**NA**	**CP**	**CP**	**CP-M**
Incidental Ingestion of Sediment	**NA**	**CP**	**CP**	**CP**
Food Chain	**NA**	**CP**	**(CP)**	**(CP)**
Drinking of Surface Water	**NA**	**NA**	**NA**	**CP-M**

ecology and environment, inc.
International Specialists in the Environment
Seattle, Washington

LEGEND
- **CP** = Complete Exposure Route
- **(CP)** = Important Only for Organic Chemicals that Biomagnify in Food Chains (such as dioxin)
- **CP-M** = Complete but Considered Minor
- **NA** = Not Applicable
- **PCP** = Pentachlorophenol

THE OESER COMPANY SUPERFUND SITE
ECOLOGICAL RISK ASSESSMENT
Bellingham, Washington

Past and Present Conditions

Figure 2-2
ECOLOGICAL CONCEPTUAL SITE MODEL

Date: 07/05/01 | Drawn by: AES | 10:START-2\01030016\S639\fig 2-2

3. ASSESSMENT ENDPOINTS AND MEASURES OF EFFECT

In an ERA, assessment endpoints are expressions of the ecological resources that are to be protected (EPA 1997). The measurements used to evaluate the risks to these resources are termed "measures of effect," and may include direct measures of effect (e.g., results of sediment toxicity tests) or measures of exposure (e.g., concentrations of chemicals in sediment and soil; EPA 1998b). Based on the site ecology, the COPCs, and the CSM, the ecological resources potentially at risk from chemical contamination at The Oeser Company site include aquatic life in Little Squalicum Creek and populations of plants, soil organisms, mammals, and songbirds that use the south slope and creek area. The assessment and measurement endpoints for these categories of ecological receptors at the site are listed below:

- **Stream Aquatic Life.** The assessment endpoint is sustained aquatic community structure, including species composition and abundance, typical of small streams with seasonally limited flow. The measures of effect are growth and survival of laboratory-reared invertebrates in toxicity tests with creek sediment and measured concentrations of COPCs in creek sediment and water, which can be compared with published toxicity benchmarks.

- **Plant and Soil-Organism Communities.** The assessment endpoints are healthy plant and soil-organism communities on the south slope and in the riparian zone. The measurement endpoints are COPC concentrations in soil samples from these areas, which can be compared to published benchmarks to estimate the potential for adverse effects.

- **Songbird and Small-Mammal Populations.** The assessment endpoints are sufficient rates of survival, growth, and reproduction of small mammals and songbirds to sustain healthy populations in the creek and south slope area. The measurement endpoints are COPC concentrations in environmental media from these areas, which can be used to model dietary exposure to site COPCs for comparison to published toxicity thresholds (no observed adverse effect levels [NOAELs] and lowest observed adverse effect levels [LOAELs]) to determine if potential exposures pose a risk to avian and mammalian species.

4. AQUATIC LIFE RISKS

The section discusses the ecological risks that facility-related chemicals may pose to benthic life (Section 4.1) and other aquatic life (Section 4.2) in Little Squalicum Creek. Sediment and surface water sampling locations are shown in Figure 4-1 and are described further in Section 2.7 and Tables 2-18 through 2-22 of the RI report (E & E 2002).

4.1 BENTHIC LIFE RISKS

The possibility that facility-related chemicals adversely may be affecting benthic life in Little Squalicum Creek was evaluated in two ways: (1) by comparing contaminant concentrations in creek sediment to available benchmarks and (2) by conducting toxicity tests with laboratory-reared organisms and creek sediment.

Concentrations of chemicals detected in creek sediment were presented and compared to benchmarks for benthic life protection in Section 4.6 of the RI report (E & E 2002) and are shown here in Table 4-1. Exceedences of sediment benchmarks for PCP, total PAHs, and dioxins/furans were observed at selected locations in the creek. Specifically, the sediment PCP concentration exceeded the PCP benchmark of 0.36 milligrams per kilogram (mg/kg) at two locations; the sediment total PAH concentration exceeded the total PAH benchmark of 3.8 mg/kg at three locations; and the sediment 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) toxicity equivalent (TEQ) concentration exceeded the National Oceanic and Atmospheric Administration 2,3,7,8-TCDD sediment benchmark of 8.8 nanograms per kilogram at most locations. However, it should be noted that the benchmarks presented in Section 4.6 of the RI report are conservative screening values. Consequently, an exceedence of these benchmarks does not imply that an adverse effect on benthic life is guaranteed, only that an adverse impact possibly may exist. In certain circumstances, sediment chemical concentrations that exceed benchmarks may not affect benthic life if site-specific factors limit contaminant bioavailability. To provide a more definitive evaluation of risks to benthic life, sediment toxicity tests also were conducted as part of the RI/FS, as described below.

Sediment toxicity was evaluated directly at 10 locations in the creek through a 10-day growth and survival test with *Hyalella azteca*, a freshwater amphipod. A site-specific background sample and a clean laboratory control sample also were tested. The results are presented and discussed in Section 4.6 of the RI report. Test organism survival in sediment from the creek was high (78 to 93%), and none of the creek sample survival rates differed significantly from the laboratory control or site-specific background sample. Growth of the test organisms in sediment from the creek was intermediate between the laboratory control and background samples. Overall, the toxicity testing results suggest that current levels of sediment contamination in Little Squalicum Creek do not pose a hazard to benthic life.

4.2 OTHER AQUATIC LIFE

Because of its limited flow and shallow depth, Little Squalicum Creek does not support a diverse and abundant community of water-column organisms. Nonetheless, salmon fingerlings occasionally are observed in the small pool that forms at the Bellingham Bay beach, and some benthic organisms also are exposed to surface water.

In Section 4.6 of the RI report, concentrations of detected chemicals in creek water were presented and compared to the United States Environmental Protection Agency (EPA) ambient water quality criteria and other applicable benchmarks, shown here in Tables 4-2 and 4-3. In July 1999, no chemicals in surface water were present at concentrations in excess of the criteria or benchmarks. In December 1999, the PCP concentration at a single location (SW05) exceeded the PCP screening benchmark of 15 micrograms per liter, and the 2,3,7,8-TCDD TEQ concentration exceeded the 2,3,7,8-TCDD benchmark for fish of 10 picograms per liter at two locations (SW04 and SW05; Figure 4-1).

It is worth noting that the total suspended solids concentration in the creek was considerably higher in December than in July 1999, probably as a result of sediment resuspension caused by the greater wintertime flow rate. This suggests that the PCP and dioxins/furans in the water in December were in particulate form and not in solution. Typically, the bioavailability of particle-bound chemicals in surface water is low.

Table 4-1

SUMMARY OF RESULTS FOR CHEMICALS DETECTED IN SEDIMENT FROM LITTLE SQUALICUM CREEK AND BACKGROUND AREAS
THE OESER COMPANY
ECOLOGICAL RISK ASSESSMENT
BELLINGHAM, WASHINGTON

Analyte	SD01	SD02	SD03	SD04	SD05	SD06	SD07	SD08	Oeser Outfall SD10	Background Birchwood Outfall SD09	Background Pond SD11	Sediment Benchmark Value	Sediment Benchmark Source*
Semivolatile Organic Chemicals (mg/kg dry weight)													
Benzoic acid	0.022 UJ	0.026 UJ	0.027 UJ	0.023 UJ	0.026 UJ	0.061 UJ	0.025 UJ	0.023 UJ	0.082	0.024 UJ	0.081 JQ	0.65	A
3&4-Methylphenol	0.011 U	0.013 U	0.008 J	0.006 J	0.012 J	0.1	0.012 U	0.003 J	0.011 U	0.037	0.054 U	0.67	A
Pentachlorophenol	0.0037 J	0.033	2 J	0.024	0.056	0.46	0.015	0.16	2.9	1.1	0.054 UJK	0.36	A
Phenol	0.011 U	0.013 U	0.013 U	0.012 U	0.013 U	0.031 U	0.012 U	0.011 U	0.011 U	0.016	0.054 U	0.42	A
Tetrachlorophenols	0.011 U	0.0054 J	0.03	0.0046 J	0.013 U	0.079	0.012 U	0.018	0.17	0.065	0.054 U	-	-
7H-Dibenzo(c,g)carbazole	0.0022 U	0.013	0.0027 U	0.0023 U	0.0026 U	0.0061 U	0.0025 U	0.0023 U	0.0022 U	0.0024 U	0.011 U	-	-
Dibenzofuran	0.011 U	0.025	0.017	0.0016 J	0.0042 J	0.035	0.0042 J	0.0066 J	0.06	0.008 J	0.054 U	2	B
PAHs (mg/kg dry weight)													
Sum of PAHs**	0.07	20.3	1.0	0.41	1.39	14.1	1.3	3.6	12.6	0.8	0.04	3.8	D
EPHs (mg/kg dry weight)													
C10-C12 Aliphatics	6.1 U	7 U	6.5 U	6.5 U	6.6 U	16 U	6.3 U	6.3 U	5.9 U	6.4 U	31 U	-	-
C10-C12 Aromatics	6.1 U	7 U	6.5 U	6.5 U	6.6 U	16 U	6.3 U	6.3 U	5.9 U	6.4 U	31 U	-	-
C12-C16 Aliphatics	6.1 U	10	6.5 U	6.5 U	6.6 U	21	6.3 U	6.3 U	5.9 U	6.4 U	31 U	-	-
C12-C16 Aromatics	6.1 U	7 U	6.5 U	6.5 U	6.6 U	16 U	6.3 U	6.3 U	5.9 U	6.4 U	31 U	-	-
C16-C18 Aliphatics	6.1 U	12	6.5 U	6.5 U	6.6 U	36	6.3 U	6.3 U	6.1	6.4 U	31 U	-	-
C16-C18 Aromatics	6.1 U	7 U	6.5 U	6.5 U	6.6 U	16 U	6.3 U	6.3 U	5.9 U	6.4 U	31 U	-	-
C18-C21 Aliphatics	6.1 U	15	7.7	6.5 U	13	76	6.3 U	6.3 U	16	6.4 U	31 U	-	-
C18-C21 Aromatics	6.1 U	30	6.5 U	6.5 U	13	110	6.3 U	9	12	6.4 U	31 U	-	-
C21-C28 Aliphatics	6.1 U	64	46	34	100	470	30	23	48	57	220	-	-
C21-C28 Aromatics	6.1 U	32	8.1	7.8	19	120	12	17	20	11	31 U	-	-
C28-C36 Aliphatics	6.1 U	65	53	51	91	390	30	25	38	63	31 U	-	-
C28-C36 Aromatics	6.1 U	50	22	26	38	170	32 J	30 J	30 J	30 J	170 J	-	-
Total EPHs (nondetects excluded)	0	278	136	119	274	1393	104	104	170	161	390	-	-
Dioxins and Furans (ng/kg dry weight)													
Toxic Equivalent Concentration***	8.9	162	191	20.5	6.1	305	53.5	122	580	9.7	3.26	8.8	E

Key is on the next page.

Note: Shading indicates: (1) if no sedment benchmark is available, the shaded value exceeds the greater of the two background concentrations; (2) if a benchmark is available, the shaded value exceeds both the benchmark and the greater of the two background concentrations.

*

A = Table 2 of Jones et al. (1997).
B = Table 5 of Jones et al. (1997).
C = Ginn and Pastorok (1992) for 1% organic carbon.
D = Threshold effects concentration for total PAHs (290 µg/g organic carbon) from Swartz (1999) for median creek sediment TOC concentration (1.3%).
E = NOAA SQuiRT tables by Buchman (1997).

** Total includes the 13 PAHs considered by Swartz (1999): naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benz(a)anthracene chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, and benzo(a)pyrene. Sum includes only detected PAHs.

*** Calculated using toxic equivalency factors (TEFs) for mammals from Van den Berg et al. (1998) and detected congener concentrations only.

Table 4-1

SUMMARY OF RESULTS FOR CHEMICALS DETECTED IN SEDIMENT FROM LITTLE SQUALICUM CREEK AND BACKGROUND AREAS
THE OESER COMPANY
ECOLOGICAL RISK ASSESSMENT
BELLINGHAM, WASHINGTON

Key:

-	= Not available.
EPHs	= Extractable petroleum hydrocarbons.
K	= Bias unkown.
J	= Estimated quantity.
µg/g	= Micrograms per gram.
ng/kg	= Nanograms per kilogram.
mg/kg	= Milligrams per kilogram.
NOAA	= National Oceanic and Atmospheric Administration.
PAHs	= Polycyclic aromatic hydrocarbons.
Q	= Result between instrument detection limit and contract required detection limit.
TOC	= Total organic carbon.
U	= Undetected (listed value is quantitation limit).

Table 4-2

ANALYTICAL RESULTS FOR CHEMICALS DETECTED IN SURFACE WATER IN JULY 1999
THE OESER COMPANY
ECOLOGICAL RISK ASSESSMENT
BELLINGHAM, WASHINGTON

Analyte	Terminal Pool SW1	Below Marine Drive Outfall SW2	Tapped Spring near Marine Drive SW3	Above Marine Drive Outfall SW4	Near Oeser Outfall SW5	Seep SW8	Background: Birchwood Outfall SW6	Background: Pond SW7	Aquatic Life Screening Benchmark: Value	Aquatic Life Screening Benchmark: Source[1]
PAHs (µg/L)										
Acenaphthene	0.04	0.11	0.0099 U	0.094	0.04	0.0049 U	0.0049 U	0.0051 U	23	C
Acenaphthylene	0.013	0.011	0.0099 U	0.0058	0.0048 U	0.0049 U	0.0049 U	0.0051 U	23*	C
Anthracene	0.016	0.015	0.013	0.025	0.0072	0.03	0.0049 U	0.0051 U	0.73	A
Benzo(a)pyrene	0.036	0.015	0.0099 U	0.0053	0.0048 U	0.0073	0.0049 U	0.0051 U	0.3	F
Benzo(b)fluoranthene	0.01 U	0.0096 U	0.0099 U	0.0072	0.0048 U	0.0049 U	0.0049 U	0.0051 U	-	-
Chrysene	0.01 U	0.0096 U	0.0099 U	0.0053	0.0048 U	0.0053	0.0049 U	0.0051 U	-	-
Fluoranthene	0.027	0.018	0.0099 U	0.03	0.028	0.011	0.0054	0.0056	6.2	C
Fluorene	0.02	0.047	0.0099 U	0.04	0.025	0.0049 U	0.0049 U	0.0051 U	3.9	A
Indeno(1,2,3-cd)pyrene	0.012	0.0096 U	0.0099 U	0.0048 U	0.0048 U	0.0073	0.0049 U	0.0051 U	-	-
2-Methylnaphthalene	0.01 U	0.0096 U	0.0099 U	0.0048 U	0.012	0.0049 U	0.0049 U	0.0051	2.1**	A
Naphthalene	0.011	0.0096 U	0.0099 U	0.0048 U	0.0063	0.0049 U	0.0049 U	0.0066	12	A
Phenanthrene	0.022	0.014	0.02	0.017	0.039	0.02	0.0049 U	0.0051 U	6.3	C
Pyrene	0.12	0.044	0.02	0.022	0.029	0.0092	0.0083	0.0045 JQ	-	-
Other SVOCs (µg/L)										
Benzoic acid	0.1 UJK	0.096 UJK	0.099 UJK	0.077	0.048 U	0.049 U	0.049 U	0.051 U	-	-
Dibenzofuran	0.0071 JQ	0.0087 JQ	0.05 U	0.0067 JQ	0.0038 JQ	0.024 U	0.025 U	0.025 U	3.7	A
2,4-Dichlorophenol	0.051 U	0.048 U	0.05 U	0.024 U	0.0077 JQ	0.024 U	0.025 U	0.025 U	36.5	B
2,4-Dimethylphenol	0.051 U	0.048 U	0.05 U	0.024 U	0.15	0.024 U	0.025 U	0.025 U	21.1	B
2-Methylphenol	0.051 U	0.048 U	0.05 U	0.024 U	0.3 JH	0.024 U	0.025 U	0.025 U	13	A
3&4-Methylphenol	0.051 U	0.048 U	0.05 U	0.0087 JQ	0.016 JQ	0.024 U	0.025 U	0.025 U	13***	A
Pentachlorophenol	0.055	0.063	0.05 U	0.027 JL	0.042 JL	0.024 UJK	0.025 UJK	0.025 UJK	15	D
Phenol	0.051 U	0.048 U	0.05 U	0.066	0.11	0.058	0.025 U	0.025 U	110	E
Tetrachlorophenols	NA	NA	NA	0.024 U	0.024 U	0.0083 JQ	0.025 U	0.025 U	15****	D
Toluene	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	NA	0.08 JQ	0.051 JQ	9.8	A
Dioxins and Furans (pg/L)										
1,2,3,4,6,7,8-HpCDD	79.143	10.713 U	13.982 U	17.442 U	131.833	203.031	10.324 U	6.036 U	-	-
OCDD	1009.773	201.989	12.647 U	289.937	1410.036	2049.482	34.886 U	63.694 U	-	-
OCDF	58.54	26.403 U	10.994 U	43.65	217.949	406.221	4.678 U	11.151 U	-	-
TCDD TEQ conc. (fish)²	0.37	0.02	0	0.03	0.30	0.45	0	0	10	B
EPHs (µg/L)		All fractions undetected.								
VPHs (µg/L)										
Methyl tert-Butyl Ether	2.7 JQ	3 JQ	2.5 JQ	3.4 JQ	3.4 JQ	NA	2.4 JQ	2.4 JQ	17	G
o-Xylene	0.69 JQ	0.64 JQ	0.47 JQ	0.66 JQ	0.78 JQ	NA	0.65 JQ	0.73 JQ	13	A

Key is on the next page.

Table 4-2

ANALYTICAL RESULTS FOR CHEMICALS DETECTED IN SURFACE WATER IN JULY 1999
THE OESER COMPANY
ECOLOGICAL RISK ASSESSMENT
BELLINGHAM, WASHINGTON

Note: Shading indicates: (1) if no screening benchmark is available, the shaded value exceeds the greater of the two background concentrations; (2) if a benchmark is available, the shaded value exceeds both the benchmark and the greater of the two background concentrations. Additional parameters and major ions not screened against background.

Key:

- \- = Not applicable.
- EPA = United States Environmental Protection Agency.
- EPHs = Extractable petroleum hydrocarbons.
- H = Bias high.
- J = Estimated value.
- K = Bias unknown.
- L = Bias low.
- µg/L = Micrograms per liter.
- NA = Not analyzed.
- PAHs = Polycyclic aromatic hydrocarbons.
- pg/L = Picograms per liter.
- Q = Result between instrument detection limit and contract required detection limit.
- SVOCs = Semivolatile organic compounds.
- U = Not detected; listed value is quantitation limit.
- VPHs = Volatile petroleum hydrocarbons.

[1]

- A = Table 1 of Suter and Tsao (1996); Tier II secondary chronic value.
- B = Table 3 of Suter and Tsao (1996); EPA Region IV chronic screening value.
- C = Table 1 of Suter and Tsao (1996); final chronic value.
- D = Chronic national ambient water quality criteria (EPA 1998a).
- E = Table 1 of Suter and Tsao (1996); calculated by the Great Lakes Water Quality Initiative.
- F = Table 1 of Suter and Tsao (1996); lowest chronic value for all organisms.
- G = EPA (1993c); chronic value for Daphnia.

[2] Calculated using toxic equivalent factors for fish from Van den Berg et al. (1998) excluding U-qualified data.

* Acenaphthene screening value.
** 1-Methylnaphthalene screening value.
*** 2-Methlyphenol screening value.
**** Pentachlorophenol screening value.

Table 4-3

ANALYTICAL RESULTS FOR CHEMICALS DETECTED IN SURFACE WATER IN DECEMBER 1999
THE OESER COMPANY
ECOLOGICAL RISK ASSESSMENT
BELLINGHAM, WASHINGTON

Analyte	Terminal Pool SW01	Below Marine Drive Outfall SW02	Tapped Spring near Marine Drive SW03	Above Marine Drive Outfall SW04	Near Oeser Outfall SW05	Seep SW08	Tapped Spring 2 SW09	Background: Birchwood Outfall SW06	Background: Pond SW07	Aquatic Life Screening Benchmark: Value	Aquatic Life Screening Benchmark: Source[1]
Polycyclic Aromatic Hydrocarbons (µg/L)											
Acenaphthene	0.072	0.059	0.0047 U	0.08	0.12	0.005 U	0.021	0.0053 U	0.018	23	C
Acenaphthylene	0.0047 U	0.0047 U	0.0047 U	0.0051 U	0.05	0.049	0.0047 U	0.0053 U	0.0047 U	23*	C
Anthracene	0.037	0.043	0.035	0.051	0.15	0.13	0.013	0.0089 JN	0.0066	0.73	A
Benzo(a)anthracene	0.015	0.0047 U	0.0047 U	0.0051 U	0.058	0.037	0.0047 U	0.0053 U	0.0047 U	0.65	E
Benzo(a)pyrene	0.015	0.032	0.0047 U	0.0051 U	0.16	0.2	0.0047 U	0.018	0.0047 U	0.3	E
Benzo(g,h,i)perylene	0.0047 U	0.0047 U	0.0047 U	0.0051 U	0.084	0.35	0.0047 U	0.0053 U	0.0047 U	-	-
Benzofluoranthenes	0.024	0.0047 U	0.0047 U	0.0051 U	0.17	0.21	0.0047 U	0.0053 U	0.0047 U	-	-
Chrysene	0.02	0.037	0.0047 U	0.031	0.12	0.12	0.0047 U	0.025	0.0047 U	-	-
Dibenzo(a,h)anthracene	0.0047 U	0.0047 U	0.0047 U	0.0051 U	0.0047 U	0.023	0.0047 U	0.0053 U	0.0047 U	-	-
Fluoranthene	0.089	0.074	0.0047 U	0.049	0.13	0.028	0.0047 U	0.044	0.0038 J	6.2	C
Fluorene	0.034	0.0047 U	0.0047 U	0.036	0.19	0.005 U	0.0047 U	0.0053 U	0.0047 U	3.9	A
Indeno(1,2,3-cd)pyrene	0.0047 U	0.0047 U	0.0047 U	0.0051 U	0.059	0.2	0.0047 U	0.0053 U	0.0047 U	-	-
2-Methylnaphthalene	0.0047 U	0.022	0.0047 U	0.03	0.26	0.005 U	0.0047 U	0.0053 U	0.0047 U	2.1**	A
Naphthalene	0.013	0.051	0.0047 U	0.062	0.18	0.007	0.0047 U	0.0053 U	0.0057 U	12	A
Phenanthrene	0.032	0.021	0.014	0.015	0.19	0.016 JN	0.011	0.023	0.0099	6.3	C
Pyrene	0.082	0.069	0.0047 U	0.072	0.17	0.083	0.0047 U	0.034	0.02	-	-
Other SVOCs (µg/L)											
4-Chloroaniline	0.024 U	0.024 U	0.024 U	0.025 U	0.024 U	0.042	0.024 U	0.026 U	0.024 U	-	-
Benzyl alcohol	0.03	0.024 U	0.024 U	0.025 U	0.024 U	0.11	0.024 U	0.026 U	0.024 U	8.6	A
Carbazole	0.047 U	0.047 U	0.047 U	0.051 U	0.075	0.05 U	0.047 U	0.053 U	0.047 U	-	-
Dibenzofuran	0.024 U	0.024 U	0.024 U	0.017 J	0.074	0.025 U	0.024 U	0.026 U	0.024 U	3.7	A
Pentachlorophenol	14	8.5	0.024 U	7.2	21	0.33	0.024 U	0.17	0.065	15	D
Tetrachlorophenols	0.46	0.26	0.0094 U	0.27	1	0.07	0.024 U	0.026 U	0.024 U	15***	D
Dioxins/furans (pg/L)											
1,2,3,4,6,7,8-HpCDD	1510.467	1650.334	18.88	2753.471	4553.618	1057.645	3.551 U	82.354	8.222 U	-	-
1,2,3,4,6,7,8-HpCDF	279.003	279.813	3.523 U	447.392	592.388	226.023	2.468 U	8.925 U	5.22 U	-	-
1,2,3,6,7,8-HxCDD	48.661	61.389	4.186 U	103.324	147.171	14.648 U	3.802 U	6.023 U	9.082 U	-	-
1,2,3,7,8,9-HxCDD	11.071 U	8.37 U	4.799 U	53.916	44.1 U	10.109 U	4.359 U	6.904 U	10.411 U	-	-
OCDD	16364.845	16392.819	200.322	26433.854	54724	11699.973	18.251 U	684.219	111.934	-	-
OCDF	1903.814	2150.551	25.507	3311.486	2791.716	1949.572	3.455 U	59.183	11.664 U	-	-
TCDD TEQ conc. (fish)²	6.614	6.917	0.041	11.774	17.701	4.683	0.000	0.157	0.011	10	B
Extractable Petroleum Hydrocarbons (µg/L)											
C16-C21 Aromatics	49 UJ	50 UJ	48 UJ	48 UJ	58 J	47 UJ	47 UJ	47 UJ	47 UJ	-	-
C21-C34 Aliphatics	49 UJ	110 J	48 UJ	58 J	63 J	60 J	47 UJ	87 J	47 UJ	-	-
C21-C34 Aromatics	49 UJ	50 UJ	48 UJ	48 UJ	47 UJ	52 J	47 UJ	47 UJ	47 UJ	-	-
Volatile Organic Analytes (µg/L)											
Benzene	0.02 U	0.02 U	0.02 U	0.02 U	0.15	0.02 U	0.02 U	0.02 U	0.02 U	46	A
m&p-Xylene	0.04 U	0.04 U	0.04 U	0.04 U	0.12	0.04 U	0.04 U	0.04 U	0.04 U	13	A
Trichloromethane	0.023	0.052	0.015 J	0.046	0.22	0.034	0.02 U	0.42	0.02 U	-	-

Key is on the next page.

Table 4-3

ANALYTICAL RESULTS FOR CHEMICALS DETECTED IN SURFACE WATER IN DECEMBER 1999
THE OESER COMPANY
ECOLOGICAL RISK ASSESSMENT
BELLINGHAM, WASHINGTON

Note: Shading indicates: (1) if no screening benchmark is available, the shaded value exceeds the greater of the two background concentrations; (2) if a benchmark is available, the shaded value exceeds both the benchmark and the greater of the two background concentrations. Additional parameters and major cations not screened against background.

Key:

-	= Not available.
EPA	= United States Environmental Protection Agency.
J	= Estimated value.
µg/L	= Micrograms per liter.
N	= Tentative identification.
pg/L	= Picograms per liter.
SVOCs	= Semivolatile organic compounds.
U	= Not detected; listed value is quantitation limit.

[1]

A = Table 1 of Suter and Tsao (1996); Tier II secondary chronic value.
B = Table 3 of Suter and Tsao (1996); EPA Region IV chronic screening value.
C = Table 1 of Suter and Tsao (1996); final chronic value.
D = Chronic national ambient water quality criteria (EPA 1998a).
E = Table 1 of Suter and Tsao (1996); lowest chronic value for all organisms.

[2] Calculated using toxic equivalency factors for fish from Van den Berg et al. (1998) with U-qualified data set to 0.

* Acenaphthene screening value.
** 1-Methylnaphthalene screening value.
*** Pentachlorophenol screening value.

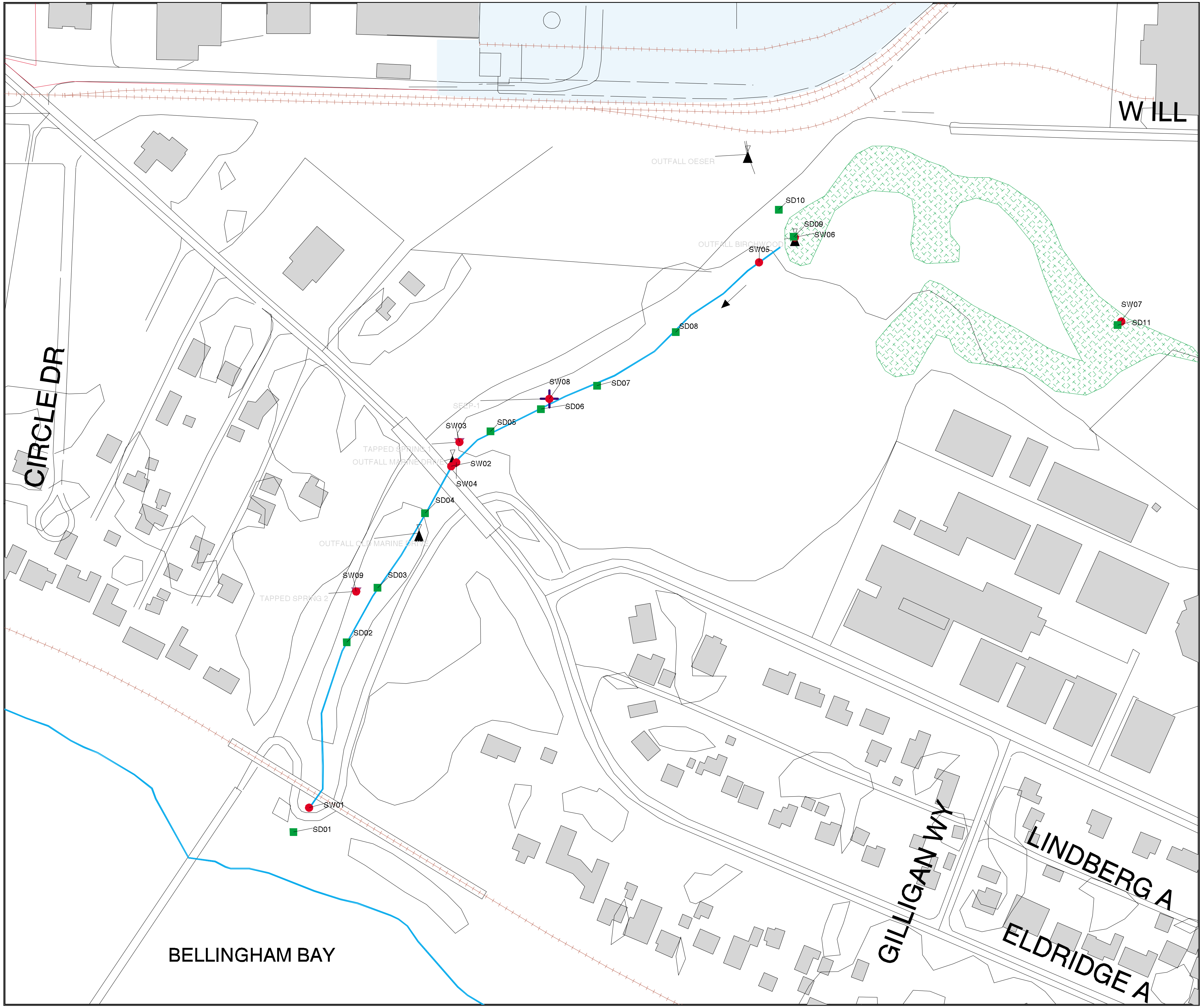


Figure 4-1

THE OESER COMPANY SUPERFUND SITE

Bellingham, Washington

Ecological Risk Assessment

Little Squalicum Creek
Sample Location Map

Legend

- The Oeser Company Facility
- Wetlands
- Surface Water, Seep, Tapped Spring Sample Location
- Sediment Sample Location
- Outfall Location
- Seep Location
- Tapped Spring Location
- Flow Direction

N W E S

0 100 200 300 400 500
Feet

MAP SOURCE

City of Bellingham - Department of Public Works
Topographic Data Date: 1988

ecology and environment, inc.
International Specialists in the Environment
Seattle, Washington

/data1/oeser/rifs/fig4-1-era.aml

5. PLANT AND SOIL FAUNA RISKS

Potential risks to plants and soil fauna were evaluated by comparing surface soil concentrations of facility-related chemicals to published benchmarks. Unfortunately, no benchmarks are available to assess the effects of dioxins/furans on plants and soil fauna, and the number of PAH benchmarks is very limited. The available benchmarks and the results of the comparisons are summarized in Table 5-1. Only surface soil samples from the south slope and creek area were screened against the benchmarks (See Figure 5-1 for sample locations.). These areas are relatively undisturbed and are vegetated with trees, shrubs, and various grasses. Soil samples from the facility property were not screened against the benchmarks since the facility itself is of little ecological value, being largely covered with asphalt and gravel.

No risks to plants or soil fauna from PCP were identified for the south slope or Little Squalicum Creek area (Table 5-1). Potential risks to these groups of receptors from PAHs appear to be limited to one sample location (SP02) on the north bank of Little Squalicum Creek (Table 5-1). The total PAH concentration at this location was in excess of 900 mg/kg, and the soil had an oily/silvery appearance and a strong petroleum odor (see Section 4.6 of the RI report for a summary of laboratory analytical data and field screening results.). However, the sample location was heavily overgrown with grasses, shrubs, and vines, and there was no visible evidence that the vegetation at this location was stressed.

Table 5-1

SUMMARY OF COMPARISONS OF SURFACE SOIL DATA TO PHYTOTOXICITY AND SOIL-FAUNA BENCHMARKS FOR THE SOUTH SLOPE AND LITTLE SQUALICUM CREEK AREA
THE OESER COMPANY
ECOLOGICAL RISK ASSESSMENT
BELLINGHAM, WASHINGTON

Chemical	Phytotoxicity Benchmark (mg/kg)[a]	Earthworm Benchmark (mg/kg)[b]	Soil Microbe Benchmark (mg/kg)[b]	Summary of Comparisons for South Slope Surface Soil	Summary of Comparisons for Little Squalicum Creek Area Surface Soil
PCP	3	6	400	No benchmark exceeded. Highest detected concentration: 0.015 mg/kg.	No benchmark exceeded. Highest detected concentration: 1.8 mg/kg.
Acenaphthene	20	NA	NA	Acenaphthene not detected in all samples.	Phytotoxicity benchmark exceeded at one location (SP02) with acenaphthene concentration of 72 mg/kg.
Fluorene	NA	30	NA	Fluorene not detected in all samples.	Earthworm benchmark exceeded at one location (SP02) with fluorene concentration of 57 mg/kg.

[a] Efroymson et al. 1997.
[b] Efroymson, Will, and Suter 1997.

Key:

mg/kg = Milligrams per kilogram.
NA = Not available.
PCP = Pentachlorophenol.

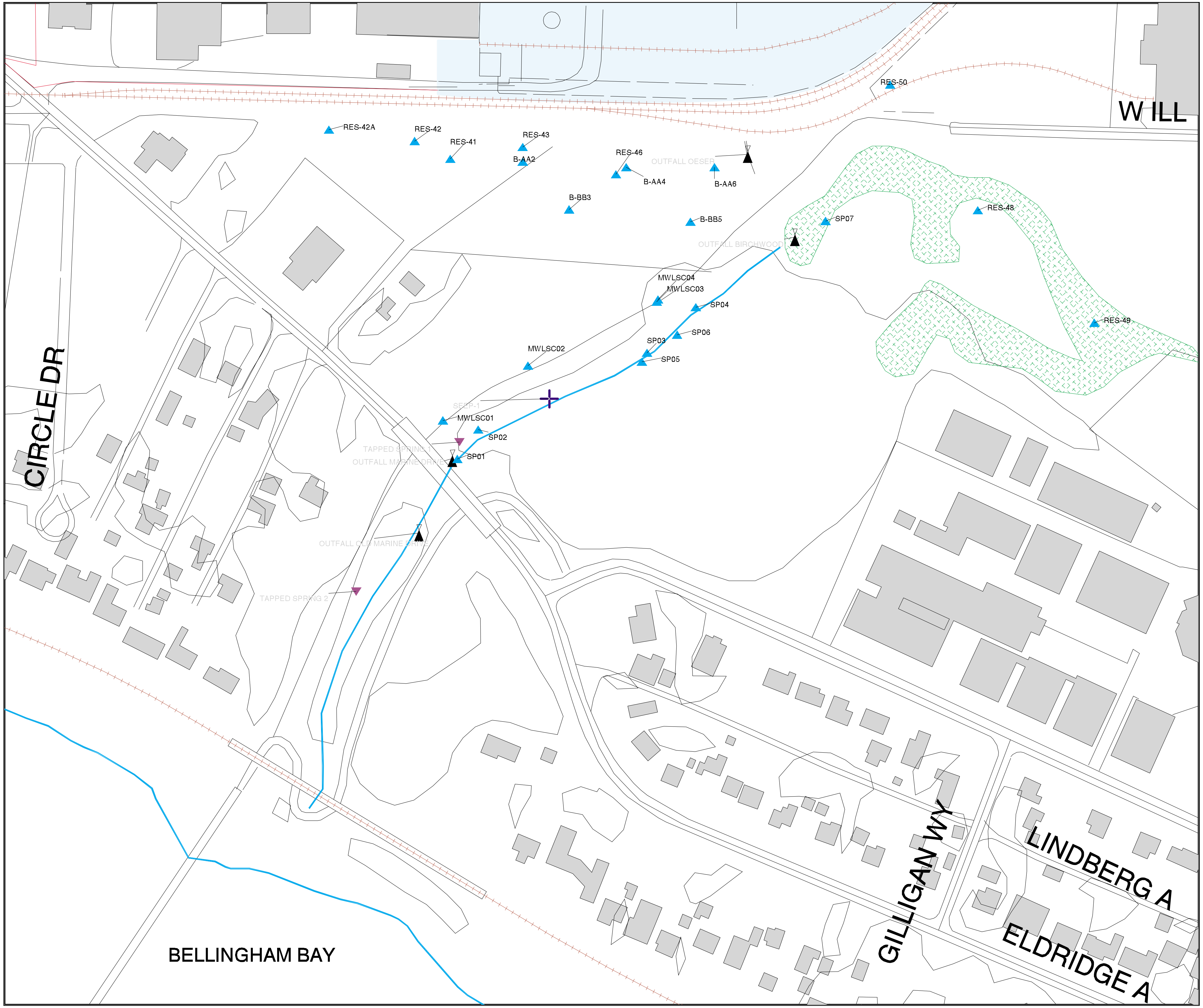


Figure 5-1

THE OESER COMPANY SUPERFUND SITE

Bellingham, Washington

Ecological Risk Assessment

Little Squalicum Creek and South Slope Surface Soil Sample Location Map

Legend

- The Oeser Company Facility
- Wetlands
- Surface Soil Sample Location
- Outfall Location
- Seep Location
- Tapped Spring Location

N
W E
S

0 100 200 300 400 500

Feet

MAP SOURCE

City of Bellingham - Department of Public Works
Topographic Data Date: 1988

ecology and environment, inc.
International Specialists in the Environment
Seattle, Washington

/data1/oeser/rifs/.aml

6. WILDLIFE RISKS

This section presents an evaluation of potential risks to wildlife at the site. The assessment was performed in accordance with federal and other available guidance for ERA (EPA 1997, 1998b; Sample, Opresko, and Suter 1996). The assessment focuses on the south slope and the Little Squalicum Creek area. Because these areas are adjacent and wildlife moves freely between them, they are treated as one exposure area for wildlife in this assessment.

The wildlife risk evaluation consists of three parts: (1) exposure assessment, (2) ecological effects assessment, and (3) risk characterization. The exposure assessment estimates wildlife exposure to facility-related chemicals from concentrations in environmental media and exposure parameters for the wildlife species. The potential toxic effects of facility-related chemicals on wildlife are summarized in the ecological effects assessment. The risk characterization combines the results of the exposure and ecological effects assessments to provide an estimate of risk to wildlife at the site.

6.1 EXPOSURE ASSESSMENT

This section discusses potential exposure to PCP, PAHs, and dioxins/furans for wildlife using the south slope and creek area. Potential receptors and exposure pathways generally were discussed in Section 2-3 and were identified in the ecological CSM (Figure 2-2). This section describes specific wildlife exposure scenarios that will be evaluated in the assessment, estimates concentrations of facility-related chemicals in exposure media, and quantifies exposure.

6.1.1 Wildlife Exposure Scenarios and Pathways

Three wildlife species representing different functional groups were selected as receptors for the assessment. The selected receptors are expected to have a high level of exposure to facility-related chemicals because of their feeding habits and small home ranges. For these receptors, this assessment quantifies exposure through the food chain and from incidental ingestion of soil or sediment. Chemical exposure from water intake was not quantified since the COCs either were not detected in surface water samples from Little Squalicum Creek or were detected at concentrations several orders of magnitude less than in sediment. Consequently, any contaminants ingested in surface water would contribute insignificantly to total exposure.

Because contamination is present in surface soil on the south slope and near the creek, wildlife feeding on soil invertebrates from these areas could be exposed by eating contaminated prey and by ingesting contaminated soil. To evaluate this scenario, a songbird, the American robin, and a small mammal, the masked shrew, that feed extensively on soil invertebrates were selected.

Because contamination is present in sediment in the creek, wildlife feeding on benthic invertebrates from the creek could be exposed by eating contaminated prey and by ingesting contaminated sediment. A common wildlife species that feeds on aquatic invertebrates, the raccoon, initially was considered as a possible receptor to be included in this assessment. However, no aquatic invertebrates large enough to attract a raccoon, such as crayfish, were observed in Little Squalicum Creek during the RI/FS fieldwork or other site visits. However, aquatic insects were found to be common in the creek. To evaluate this scenario, an insectivorous songbird, the barn swallow, was selected.

Specific information on each species is presented below:

- **American Robin.** The American robin (*Turdus migratorius*) is a common resident of open areas, woodland edges, and early successional habitats (EPA 1993a). The makeup of its diet varies seasonally, with invertebrates making up the majority of food items during the spring and early summer. Robins feed on the ground, searching the soil and leaf litter for invertebrates. Robins establish small territories during the breeding season and could reside entirely in the area provided by the south slope and creek. Northern populations typically winter in southern locations. Wahl (1995) reports that the American robin is a common summer resident in Whatcom County, arriving in February and staying until October.

- **Masked Shrew.** The masked shrew (*Sorex cinereus*) is the most common shrew in moist forests, open country, and brush in the northern United States and throughout Canada and Alaska (EPA 1993a). It feeds primarily on invertebrates. The home range of a masked shrew is small, and it could reside entirely in the area provided by the south slope and creek.

- **Barn Swallow.** The barn swallow (*Hirundo rustica*) is insectivorous and is known to consume adult aquatic insects in riparian and lacustrine settings (Bent 1963). Barn swallows at the site are conservatively assumed to feed on adult forms of aquatic insects from Little Squalicum Creek. Barn swallows also could be exposed to chemicals in creek sediment while collecting mud for nest building. Barn swallows reside in the Bellingham area from mid-April to mid-October (Wahl 1995).

6.1.2 Exposure Point Concentrations

Table 6-1 lists exposure point concentrations (EPCs) for PCP, total PAHs, and dioxins/furans (as the 2,3,7,8-TCDD TEQ concentration) for surface soil, sediment, and selected wildlife prey items. COPCs were assumed to be present in samples in which they were not detected using a surrogate concentration equal to one-half the sample detection limit, as recommended by the EPA (EPA 1996). Total PAH concentrations were determined by summing the concentrations of carcinogenic PAHs and noncarcinogenic PAHs described in Section 4 of the RI report (E & E 2002). Surface soil EPCs were calculated from 24 surface soil samples collected from the south slope and creek area (Figure 5-1). Surface soil EPC locations include:

MWLSC01	SP03	B-AA6	RES-42A
MWLSC02	SP04	B-BB3	RES-43
MWLSC03	SP05	B-BB5	RES-46
MWLSC04	SP06	B-CC4	RES-48
SP01	B-AA2	RES-41	RES-49
SP02	B-AA4	RES-42	RES-50

Sediment EPCs were calculated from nine of 11 sediment samples from Little Squalicum Creek (the two background sediment samples [SD9 and SD11] were not used). Because the variance of these data sets was high (owing to the occurrence of hot spots), the 95% upper confidence limit (UCL) of the mean often was greater than the maximum concentration. Consequently, the 95% UCLs were not used as EPCs for surface soil and sediment. The maximum concentrations also were not used as EPCs since doing so would result in wildlife risk estimates that assume that each receptor spends 100% of its time at the most contaminated location, a situation that seems unlikely. Consequently, the arithmetic average of the concentration data was selected as the most realistic value on which to base the exposure estimates for surface soil and for sediment for wildlife using the south slope and creek area. Chemicals measured in oligochaetes in the bioaccumulation test (see Section 4.6 of the RI report, E & E 2002) were used as an estimate of adult aquatic-insect EPCs (Table 6-1). The use of measured concentrations of COPCs in oligochaetes avoids the uncertainty associated with modeling chemical residues in invertebrate prey for the wildlife risk assessment.

COPC concentrations in soil invertebrates were estimated using a bioaccumulation factor (BAF) that relates the concentration in invertebrates to the concentration in soil. Earthworms were chosen as a representative soil invertebrate because they are abundant in most soils, are important in the diets of shrews and robins, and have been well studied. A model presented in Menzie *et al.* (1992) was used to calculate earthworm BAFs. The model predicts BAFs based on the organic content (f_{oc}) of the soil and the lipid content of the earthworm (Y_L) using the following equation:

$$BAF = Y_L/(0.66f_{oc}).$$

The organic content of the soil was measured for 10 surface soil samples collected from the south slope and creek area; the average f_{oc} for the 10 samples was 3.1%. The lipid content of earthworms is assumed to be 2% (Menzie *et al.* 1992). The BAF for earthworms is presented in Table 6-1.

6.1.3 Exposure Estimates

The total chemical exposure for wildlife receptors was calculated as the sum of exposures from diet and from incidental soil/sediment ingestion. Dietary exposure is calculated by multiplying the chemical concentration in each food item by its fraction of the total diet and summing the contributions from all items. This sum is then multiplied by the receptor's site use factor (SUF), exposure duration (ED), and ingestion rate (IR); and divided by the receptor's body weight (BW), as shown in the following equation:

$$EE_{diet} = ([(P_1 \text{ x } T_1) + (P_2 \text{ x } T_2) + \ldots (P_n \text{ x } T_n)] \text{ x } SUF \text{ x } ED \text{ x } IR)/BW$$

where:

EE_{diet} = Estimated exposure from diet (mg/kg/day);
P_n = Percentage of diet represented by food item ingested;
T_n = Tissue concentration in food item n (mg/kg dry weight);
SUF = Site use factor (unitless);
ED = Exposure duration (unitless), equal to fraction of year spent at site;
IR = Ingestion rate of receptor (kilograms [kg]/day in dry weight); and
BW = Body weight of receptor (kg in fresh weight).

IR, home range, and BW for the robin, shrew, and swallow were taken from EPA (1993a); Sample and Suter (1994); and Sample, Opresko, and Suter (1996). The values are presented in

Table 6-2. The makeup of the diet of the receptor species conservatively was assumed to consist entirely of invertebrates from the site: 100% earthworms for the robin and shrew and 100% aerial adult aquatic insects for the swallow (Table 6-2). Contaminant concentrations in prey items were estimated as discussed above.

The SUF indicates the portion of an animal's home range that would be represented by the site. If the home range is larger than the site, the SUF equals the site area divided by the home range area. If the site area is greater than or equal to the home range, the SUF is equal to 1. The south slope and creek areas combined provide an area greater than the home ranges of the wildlife receptor species. Consequently, the SUF was set equal to 1.0 for each receptor.

ED is the percentage of the year spent in the site area by the receptor species. The shrew is a year-round resident, with an ED equal to 1.0. The robin and swallow were assigned ED values of 0.75 and 0.5, respectively, based on their migratory behavior in Whatcom County, as described by Wahl (1995).

Wildlife exposure to facility-related chemicals through incidental soil/sediment ingestion was estimated in a manner similar to dietary exposure: the soil EPC was multiplied by soil ingestion and then multiplied by the SUF, ED, and IR and divided by BW. Soil/sediment ingestion estimates for the endpoint species were taken from Sample and Suter (1994) and Sample, Opresko, and Suter (1996) and are presented in Table 6-2.

The total exposure for a receptor is the sum of exposure from diet and soil/sediment ingestion, as represented by the following equation:

$$EE_{total} = EE_{diet} + EE_{soil/sediment}$$

where:

EE_{total} = Total exposure (mg/kg/day),

EE_{diet} = Estimated exposure from diet (mg/kg/day), and

$EE_{soil/sediment}$ = Estimated exposure from soil/sediment ingestion (mg/kg/day).

The calculated exposure estimates and their significance are discussed in the following sections.

6.2 ECOLOGICAL EFFECTS ASSESSMENT

This section establishes toxicity reference values (TRVs) for the wildlife receptors being evaluated. The TRVs were derived from toxicity studies reported in scientific literature. The wildlife TRVs represent NOAELs or LOAELs for each contaminant for each receptor. Toxicity values that represent chronic NOAEL exposures are preferred in deriving TRVs. If only a LOAEL is available, or if no chronic studies are available, the toxicity value is multiplied by an uncertainty factor ranging from 0.01 to 1 to extrapolate a chronic NOAEL.

Toxicity results from laboratory studies often are expressed as a concentration in food (e.g., mg/kg). This concentration must be converted to a dose (e.g., mg chemical/kg BW/day) to allow for a comparison among species of various body sizes. This conversion is performed by multiplying the concentration in diet by the food IR (which may come from measurements made in the toxicity study or from published values for the test species) and then dividing by the test organism's BW (also taken from the study or estimated from literature).

For mammals, differences in body size between the test species and the receptor species also can be a source of uncertainty. Therefore, the test species NOAEL is modified by a body scaling factor to calculate the wildlife species NOAEL (Sample, Opresko, and Suter 1996). Wildlife species NOAELs were calculated using the following equation:

$$TRV = NOAEL_W = NOAEL_T \text{ x } (BW_T/BW_W)^{1/4}$$

where:

$NOAEL_W$	= No observed adverse effect level for wildlife species (mg/kg/day),
$NOAEL_T$	= No observed adverse effect level for test species (mg/kg/day),
BW_T	= Body weight of test species (kg),
BW_W	= Body weight of wildlife species (kg), and
$(BW_T/BW_W)^{1/4}$	= Body scaling factor.

The same approach is used to adjust LOAELs for BW. For birds, recent research has indicated that body-size scaling is not appropriate; therefore, toxicity values for the robin and swallow were not adjusted using this technique (Mineau, Collins, and Baril 1996).

Table 6-3 lists the TRVs for the wildlife receptors and chemicals considered in this assessment. Most of the TRVs were derived from toxicity data presented in Sample, Opresko, and Suter (1996). Sample, Opresko, and Suter (1996) list a mammalian TRV for only one PAH, benzo(a)pyrene. The mammalian TRV for this PAH was used as a surrogate for all PAHs. No TRV was found for the effects of PCP on birds.

Avian TRVs for PAHs are not provided in Sample, Opresko, and Suter (1996). However, a study by Patton and Dieter (1980) examined the effects of a mixture of PAHs on liver function in ducks. The mixture of PAHs was representative of light crude oil and included many of the individual PAH compounds detected in soil and sediment at The Oeser Company site. Increased liver weights were observed at a concentration of 4,000 parts per million (ppm) in the diet, but no effects were seen on survival, growth, or organ histopathology. No effects on any of these parameters were observed at the lower concentration of 400 ppm in the diet. Therefore, the dietary concentration of 400 ppm PAHs is used herein as a NOAEL for exposure of birds to total PAHs. This NOAEL is considered chronic since it is based on a test duration of seven months.

To derive a TRV for total PAHs from the NOAEL in diet, the 400 ppm dietary concentration is converted to a daily dose by multiplying the NOAEL by the IR (0.1 kg/day) and dividing by the BW (1 kg) of a mallard (Sample, Opresko, and Suter 1996), which results in a chemical dose of 40 mg/kg/day (Table 6-4). This dose is considered to be the TRV for total PAHs for avian receptors. Because this TRV represents the safe dose for a mixture of PAHs, it will be used to evaluate the potential toxicity of the total PAH concentration in wildlife food items and soil/sediment.

6.3 WILDLIFE RISK CHARACTERIZATION

The potential risks posed by facility-related chemicals were evaluated by calculating a hazard quotient (HQ) for each contaminant for each endpoint species. The HQ for all pathways was determined by dividing the total exposure from all pathways (EE_{total}) by the appropriate TRV for the endpoint species and contaminant, as shown in the following equation:

$$HQ = EE_{total}/TRV$$

HQs for each receptor were calculated based on both the NOAEL TRV and LOAEL TRV, and are abbreviated as HQ_{NOAEL} and HQ_{LOAEL}, respectively. For a given receptor and chemical, a HQ_{NOAEL} greater than 1.0 indicates that the estimated exposure exceeds the highest dose at which no adverse effects were observed. A HQ_{LOAEL} greater than 1.0 suggests that an adverse affect is possible. Table 6-4 presents the estimated exposure from food and soil/sediment ingestion, the total exposure, and the calculated HQs for the American robin, barn swallow, and masked shrew.

The wildlife risk analysis suggests that insectivorous small mammals and songbirds using the south slope and creek area may be at risk from facility-related chemicals. The risk estimates are greatest for the masked shrew. For this receptor, the HQ_{LOAEL} exceeds 1.0 for both total PAHs and 2,3,7,8-TCDD, and the HQ_{NOAEL} for PCP exceeds 1.0 (Table 6-4). The potential risks are lower for the American robin and barn swallow. For the robin, the HQ_{NOAEL} exceeds 1.0 for both 2,3,7,8-TCDD and total PAHs, but only marginally for total PAHs (Table 6-4). For the barn swallow, only the HQ_{NOAEL} for 2,3,7,8-TCDD is greater than 1.0 (marginally). HQs could not be calculated for the robin and swallow for PCP because reliable avian toxicity data are not available for this chemical.

Table 6-1

EXPOSURE POINT CONCENTRATIONS FOR THE WILDLIFE RISK EVALUATION
THE OESER COMPANY
ECOLOGICAL RISK ASSESSMENT
BELLINGHAM, WASHINGTON

Chemical	Surface Soil EPC (dry)[a]	Earthworm BAF	Earthworm EPC (wet)[a]	Sediment EPC (dry)[a]	Aquatic Insect EPC (wet)[a]
PCP	0.392	0.98	0.384	0.628	2.1
Total PAHs	46.08	0.98	45.16	6.823	4.60
2,3,7,8-TCDD TEQ concentration (mammals)[b]	145.5	0.98	142.6	181.9	62.303
2,3,7,8-TCDD TEQ concentration (birds)[b]	65.53	0.98	64.23	87.31	43.56

[a] mg/kg for PCP and 3PAHs, ng/kg for 2,3,7,8 TCDD TEQ concentrations.
[b] Calculated using TEFs from Van den Berg *et al.* (1998). One-half detection limit used for nondetected congeners.

Key:

BAF = Bioaccumulation factor.
EPC = Exposure point concentration.
mg/kg = Milligrams per kilogram.
ng/kg = Nanograms per kilogram.
PAHs = Polycyclic aromatic hydrocarbons.
PCP = Pentachlorophenol.
TCDD = Tetrachlorodibenzo-*p*-dioxin.
TEF = Toxicity equivalency factor.
TEQ = Toxicity equivalent.

Table 6-2

EXPOSURE PARAMETERS FOR SELECTED WILDLIFE RECEPTORS
THE OESER COMPANY
ECOLOGICAL RISK ASSESSMENT
BELLINGHAM, WASHINGTON

Species	Diet	Soil Intake (kg/day dry)	Home Range (ha)	Exposure Duration (unitless)	Food Ingestion (kg/day wet)	Body Weight (kg)
American Robin[a]	100% earthworms	0.0097	0.42	0.75	0.093	0.077
Masked Shrew[b]	100% earthworms	0.00063	0.39	1	0.0048	0.0045
Barn Swallow[c]	100% adult aquatic insects	0.00024	0.5	0.5	0.012	0.0159

[a] Home range (territory), food ingestion, and body mass taken without modification from Sample and Suter (1994). Soil intake modified from Sample and Suter (1994) for diet of 100% earthworms. Exposure duration based on observations in Wahl (1995).

[b] Body weight from Burt and Grossenheider (1976). Food ingestion rate calculated from body weight as described by Sample, Opresko, and Suter (1996) and assumption of 70% moisture content for food. Soil intake based on soil consumption of 13% of diet, as for short-tailed shrew (Sample and Suter 1994). Home range from Sample and Suter (1994) for short-tailed shrew.

[c] Body weight and food ingestion from Sample, Opresko, and Suter (1996) for rough-winged swallow (*Stelgidopteryx serripennis*). Soil intake assumed to be 2% of food ingestion. Home range of 0.5 ha assumed. Exposure duration based on observations in Wahl (1995).

Key:

ha = Hectares.
kg = Kilogram.

Table 6-3

SUMMARY OF TOXICITY REFERENCE VALUES FOR WILDLIFE SPECIES
THE OESER COMPANY
ECOLOGICAL RISK ASSESSMENT
BELLINGHAM, WASHINGTON

Chemical	Receptor	Endpoint	Effect	Chronic TRV	Source/Remark
2,3,7,8-TCDD	American Robin	NOAEL	Reproduction	14 ng/kg/day	Sample, Opresko, and Suter (1996).
		LOAEL	Reproduction	140 ng/kg/day	Sample, Opresko, and Suter (1996).
	Barn Swallow	NOAEL	Reproduction	14 ng/kg/day	Sample, Opresko, and Suter (1996); for rough-winged swallow
		LOAEL	Reproduction	140 ng/kg/day	Sample, Opresko, and Suter (1996); for rough-winged swallow
	Masked Shrew	NOAEL	Reproduction	2.97 ng/kg/day	Sample, Opresko, and Suter (1996); adjusted for body weight of masked shrew
		LOAEL	Reproduction	29.7 ng/kg/day	Sample, Opresko, and Suter (1996); adjusted for body weight of masked shrew
Total PAHs	American Robin	NOAEL	Hepatic	40 mg/kg/day	Patton and Dieter (1980); see text
		LOAEL	Hepatic	400 mg/kg/day	Patton and Dieter (1980); see text
	Barn Swallow	NOAEL	Hepatic	40 mg/kg/day	Patton and Dieter (1980); see text
		LOAEL	Hepatic	400 mg/kg/day	Patton and Dieter (1980); see text
Benzo(a)pyrene	Masked Shrew	NOAEL	Reproduction	1.61 mg/kg/day	Sample, Opresko, and Suter (1996); adjusted for body weight of masked shrew
		LOAEL	Reproduction	16.1 mg/kg/day	Sample, Opresko, and Suter (1996); adjusted for body weight of masked shrew
Pentachlorophenol	American Robin	NOAEL	NA	NA	NA
		LOAEL	NA	NA	NA
	Barn Swallow	NOAEL	NA	NA	NA
		LOAEL	NA	NA	NA
	Masked Shrew	NOAEL	Reproduction	0.386 mg/kg/day	Sample, Opresko, and Suter (1996); adjusted for body weight of masked shrew
		LOAEL	Reproduction	3.86 mg/kg/day	Sample, Opresko, and Suter (1996); adjusted for body weight of masked shrew

Key:

LOAEL = Lowest observed adverse effect level.
mg/kg = Milligrams per kilogram.
NA = Not available.
ng/kg = Nanograms per kilogram.
NOAEL = No observed adverse effect level.
PAHs = Polycyclic aromatic hydrocarbons.
TCDD = Tetrachlorodibenzo-p-dioxin.
TRV = Toxicity reference value.

Table 6-4

EXPOSURE ESTIMATES AND HAZARD QUOTIENTS FOR WILDLIFE RECEPTORS
THE OESER COMPANY
ECOLOGICAL RISK ASSESSMENT
BELLINGHAM, WASHINGTON

Chemical	Estimated Exposure[a]			NOAEL		LOAEL	
	Diet	Soil[b]	Total	TRV[a]	HQ	TRV[a]	HQ
Masked Shrew							
PCP	0.410	0.054	0.463	0.386	**1.20**	3.86	0.12
Total PAHs	48.17	6.32	54.49	1.61	**33.85**	16.1	**3.38**
2,3,7,8-TCDD TEQ concentration	152.1	19.96	172.1	2.97	**57.94**	29.7	**5.79**
American Robin							
PCP	0.348	0.036	0.384	NA	NA	NA	NA
Total PAHs	40.91	4.27	45.18	40	**1.13**	400	0.11
2,3,7,8-TCDD TEQ concentration	58.18	6.07	64.25	14	**4.59**	140	0.46
Barn Swallow							
PCP	0.792	0.005	0.797	NA	NA	NA	NA
Total PAHs	1.74	0.051	1.79	40	0.05	400	0.005
2,3,7,8-TCDD TEQ concentration	16.44	0.66	17.10	14	**1.22**	140	0.12

[a] Units: mg/kg body weight/day for total PAHs and PCP; ng/kg body weight/day for 2,3,7,8-TCDD.
[b] Sediment for swallow.

Key:

HQ = Hazard quotient.
LOAEL = Lowest observed adverse affect level.
mg/kg = Milligrams per kilogram.
NA = Not available.
ng/kg = Nanograms per kilogram.
NOAEL = No observed adverse affect level.
PAHs = Polycyclic aromatic hydrocarbons.
PCP = Pentachlorophenol.
TEQ = Toxicity equivalent.
TCDD = Tetrachlorodibenzo-p-dioxin.
TRV = Toxicity reference value.

7. UNCERTAINTIES IN THE ECOLOGICAL RISK ASSESSMENT

Benthic Life Risks -- Uncertainty in the finding of no effect on survival and growth is considered low because toxicity tests were used to directly evaluate these parameters. However, the test method used in this assessment did not evaluate effects on reproduction of benthic invertebrates. Such testing protocols were not developed fully at the time the RI/FS sampling was conducted. Consequently, the possibility that current levels of sediment contamination in Little Squalicum Creek may affect benthic-invertebrate reproduction remains an open issue. However, numerous benthic-invertebrate taxa, including caddis fly larvae, midge larvae, amphipods, and snails, were observed in Little Squalicum Creek during the RI fieldwork. This observation suggests that the creek supports self-reproducing populations of benthic organisms.

Other Aquatic Life Risks -- Possible effects of surface water contamination on aquatic life in Little Squalicum Creek were evaluated by comparing contaminant concentrations in surface water samples with criteria for aquatic life protection. Sample concentrations that exceeded criteria were assumed to pose a potential risk. However, predictions of risk based on this comparative method are not always borne out by additional testing because site-specific factors can limit contaminant bioavailability. Consequently, there is some uncertainty regarding the risks posed by surface water concentrations of PCP and dioxins/furans that exceeded criteria at selected sampling locations in December 1999.

Plant and Soil Fauna Risks -- Risks to these receptor groups were evaluated by comparing contaminant concentrations in surface soil samples to available phytotoxicity and soil-fauna benchmarks. Unfortunately, no benchmarks are available for the effects of dioxins/furans on plants and soil fauna, so the risks posed by dioxins/furans to these receptor groups at the site are unknown. In addition, the number of phytotoxicity and soil-fauna benchmarks for individual PAHs are few and of questionable reliability. Consequently, there is substantial uncertainty regarding the risks posed to these receptor groups by total PAHs.

Wildlife Risks -- Uncertainties are associated with several aspects of the wildlife risk assessment. A large part of the uncertainty comes from the use of literature values as a basis for estimating exposure and toxicity at the site. Uncertainty in the wildlife exposure estimates may result from the use of literature-based estimates for food intake, incidental soil/sediment ingestion, and home range size, all of which are derived from a limited number of published reports. While site conditions may result in variability, the values selected for the risk assessment are assumed to be representative for the species selected for evaluation. Uncertainty also may result from the limited amount of toxicity data for certain chemicals, which necessitated the use of some chemicals as surrogates for others or prevented an evaluation of risks for some chemicals to some receptors. For example, when estimating risks to the shrew from PAHs, it was assumed that all PAHs had the same toxicity as benzo(a)pyrene. This assumption most likely results in a conservative estimate of risk given what is known about the relative toxicity of benzo(a)pyrene versus other PAHs in humans. Lastly, uncertainty may result from assumptions made about the diets of the wildlife species evaluated in this assessment. For the shrew and robin, the assumption of a diet consisting entirely of earthworms is conservative. In addition to earthworms, shrews consume other invertebrates (e.g. slugs, snails, centipedes, and various insects), fungi, plant materials, and small mammals (USEPA 1993a). Similarly, robins also consume other invertebrates (e.g. sowbugs, spiders, and various insects) and plant materials (USEPA 1993a). These foods are less intimately associated with the soil matrix than earthworms, and thus accumulate lesser amounts of soil contamination. For the swallow, the assumption of a diet consisting entirely of adult aquatic insects (post emergence) from Little Squalicum Creek also is conservative. In reality, insectivorous songbirds near the site consume insects from terrestrial areas in addition to insects that originate from the creek.

8. SUMMARY OF ECOLOGICAL RISKS

Benthic Life Risks -- Current levels of sediment contamination in Little Squalicum Creek do not appear to pose a threat to benthic life based on results of sediment toxicity tests with creek sediment. Test organism (*Hyalella azteca*) survival in sediment from the creek was high (78 to 93%) and no different than control samples. In addition, test organism growth was not impaired.

Other Aquatic Life Risks -- Surface water samples were collected from Little Squalicum Creek in July and December 1999. In July 1999, no chemicals in surface water were present at concentrations in excess of water quality criteria for aquatic life protection. In December 1999, the criteria for PCP and dioxins/furans were marginally exceeded at selected locations, apparently as a result of higher concentrations of suspended sediment in the creek at this time. Typically, the bioavailability of particle-bound chemicals in surface water is low. However, even in the absence of chemical contamination from the Oeser facility and City of Bellingham stormwater outfalls, it seems unlikely that the creek would support a diverse community of aquatic biota given its shallow depth and current flow conditions.

Plant and Soil Fauna Risks -- No risks to plants or soil fauna from PCP were identified for the south slope or Little Squalicum Creek area. For PAHs, potential risks to plants and soil fauna appear to be limited to a single sample location (SP02; Figure 5-1) on the north bank of Little Squalicum Creek with a highly elevated total PAH concentration (960 mg/kg). However, the location was heavily overgrown and there was no indication that the vegetation was stressed.

Wildlife Risks -- Individual small mammals and songbirds which feed extensively on earthworms and other soil invertebrates may be at risk from facility-related chemicals present in surface soil on the south slope and near the creek. Potential risks may exist for the masked shrew from PCP (HQ 1.2), PAHs (HQ 34), and dioxins/furans (HQ 58) and for the American robin from PAHs (HQ 1.1) and dioxins/furans (HQ 4.6). Potential risks appear to be minimal for insectivorous songbirds that consume adult forms of aquatic insects (post emergence) from Little Squalicum Creek. Although a NOAEL-based HQ of 1.2

was calculated for the barn swallow for exposure to dioxins/furans, the estimated total exposure was an order of magnitude less than the LOAEL.

Synopsis of Effects on Assessment Endpoints **--** The assessment endpoint for the creek was the maintenance of a healthy aquatic community typical of a small stream with limited flow. This endpoint was evaluated by examining impacts to benthic invertebrates and other aquatic life as described above. The findings suggest that current levels of water and sediment contamination in Little Squalicum Creek do not pose a serious threat to this assessment endpoint. For the south slope and creek riparian zone, the assessment endpoints were: (1) maintenance of healthy plant and soil-organism communities and (2) sufficient rates of growth, survival, and reproduction of small mammals and songbirds to sustain healthy populations in these areas. Regarding plant and soil-organism communities, potential risks were identified only at a single sample location (SP02) on the north bank of the creek. Elsewhere on the south slope and near the creek, plant and soil-organism communities should not be affected adversely by facility-related chemicals. Regarding the health of small-mammal and songbird populations, potential risks were identified for wildlife species that feed extensively on soil invertebrates. For such receptors, the level of dioxins/furans and PAHs at a single sample location contributed most to the estimated risks. Consequently, because the soil contamination is restricted to a small area, it is unlikely to pose a threat to the populations of small mammals and songbirds feeding on soil invertebrates in the site vicinity, although a few individuals possibly could be affected if they were to forage only in the most contaminated area (a situation that seems unlikely).

9. REFERENCES

Bent, A., 1963, *Life Histories of North American Flycatchers, Larks, Swallows, and their Allies,* Dover Publications, Inc., New York, New York.

Buchman, M., 1997, *Screening Quick Reference Tables (SQuiRT)*, NOAA Hazmat Report 97-2, NOAA, Seattle, Washington.

Burt, W. H., and R.P. Grossenheider, 1976, *A Field Guide to the Mammals*, Houghton Mifflin Company, Boston, Massachusetts.

City of Bellingham Department of Public Works, Engineering Division, 1988, topographic map, Section 23, T38N, R2E, Willamette meridian, Bellingham, Washington.

Ecology and Environment, Inc. (E & E), April 2002, *The Oeser Company Superfund Site Remedial Investigation Report*, prepared by E & E, for EPA, Region 10, Seattle, Washington.

———, 1999, *The Oeser Company Superfund Site Remedial Investigation/Feasibility Study Work Plan*, TDD: 97-08-0007, prepared by E & E, Seattle, Washington, for EPA, Region 10.

Efroymson, R.A., M.E. Will, and G.W. Suter, 1997, *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes: 1997 Revision*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, ES/ER/TM-126/R2.

Efroymson, R.A., M.E. Will, G.W. Suter, and A.C. Wooten, 1997, *Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, ES/ER/TM-85/R3.

Ginn, T.C., and R.A. Pastorik, 1992, Assessment and Management of Contaminated Sediments in Puget Sound, *Sediment Toxicity Assessment*, Burton, G.A. (ed.), pp. 371-402, Lewis Publishers, Ann Arbor, Michigan.

Jones, D.S., G.W. Suter, and R.N. Hull, 1997, *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, ES/ER/TM-95/R4.

Larry Steele & Associates, December 9, 1997, land survey, The Oeser Company Facility, Bellingham, Washington, Bellingham, Washington.

Menzie, C., D. Burmaster, J. Freshman, and C. Callahan, 1992, Assessment of methods for estimating ecological risk in the terrestrial component: a case study at the Baird and McGuire superfund site in Holbrook, Massachusetts, *Environmental Toxicology and Chemistry*, 11:245-260.

Mineau, P., B. Collins, and A. Baril, 1996, On the use of scaling factors to improve interspecies extrapolation of acute toxicity in birds, *Regulatory Toxicology and Pharmacology*, 24: 24-29.

Patton, J., and M. Dieter, 1980, Effects of petroleum hydrocarbons on hepatic function in the duck, *Comparative Biochemical Physiology*, 65C:33-36.

Sample, B.E., M.S. Aplin, R.A. Efroymson, G.W. Suter, and C.J.E. Welsh, 1997, *Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, ORNL/TM-13391.

Sample, B., D. Opresko, and G. Suter, 1996, *Toxicological Benchmarks for Wildlife: 1996 Revision*, Risk Assessment Program, Health Sciences Research Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, ES/ER/TM-86/R3.

Sample, B., and G. Suter, 1994, *Estimating Exposure of Terrestrial Wildlife to Contaminants*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, ES/ER/TM-125.

Suter, G.W., and C.L. Tsao, 1996, *Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision*, Oak Ridge National Laboratory, Oak Ridge, Tennessee, ES/ER/TM-96/R2.

Swartz, R.C., 1999, Consensus Sediment Quality Guidelines for Polycyclic Aromatic Hydrocarbons, *Environmental Toxicology and Chemistry*, 18:780-787.

United States Environmental Protection Agency (EPA), December 10, 1998a, *National Recommended Water Quality Criteria; Republican*, Federal Register, Vol. 63, No. 237.

———, 1998b, *Guidelines for Ecological Risk Assessment*, Risk Assessment Forum, USEPA, Washington, D.C., EPA/630/R-95/002F.

———, 1997, *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final*, Environmental Response Team, Edison, New Jersey.

———, 1996, *Supplemental Risk Assessment Guidance for Superfund*, Region 10, Office of Environmental Assessment, Risk Evaluation Unit, Seattle, Washington.

———, 1993a, *Wildlife Exposure Factors Handbook, Volume I of II*, USEPA Office of Research and Development, Washington, D.C., EPA/600/R-93/187A.

———, 1993b, *Wildlife Exposure Factors Handbook, Volume II of II*, USEPA Office of Research and Development, Washington, D.C., EPA/600/R-93/187B.

———, 1993c, *Technical Information Review, Methyl Tertiary Butyl Ether (CAS No. 1634-04-4)*, Office of Pollution Prevention and Toxics, USEPA, Washington, D.C.

Van den Berg, M. L. Birnbaum, A.T.C. Bosveld, B. Burnstrom, P. Cook, M. Freely, J.P. Giesy, A. Hanberg, R. Hasegawa, S.W. Kennedy, T. Kubiak, J.C. Larsen, F.X. Rolaf van Leeuwen, A.K.

Djien Liem, C. Nolt, R.E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tysklind, M. Younes, F. Waern, and T. Zacharewski, 1998, Toxic Equivalency Factors (TEFs) for PCBs, PCDDs, PCDFs for Humans and Wildlife, *Environmental Health Perspectives*, 106:775-792.

Wahl, T.R., 1995, *Birds of Whatcom County, Status and Distribution*, printed by Print Shop, Lyden, Washington, Copyright held by T.R. Wahl, ISBN 0-9652415-0-5.